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In situ analytical chemistry for the future exploration of Titan

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The complex organic chemistry on going at Titan makes it one of the most fascinating objects in the Solar System. Studying the chemical processes that occur on Titan can improve our understanding of processes that may have occurred on an early Earth as simple molecules formed ever more complex organics leading to the eventual development of life. Cassini measurements [5] have shown that organic molecules with a mass >10 000 Da. are produced in the upper atmosphere of Titan due to photolysis and cause the distinctive orange-brown haze associated with Titan's atmosphere.

Terrestrial analogues of Titan organic material have been produced by cold plasma discharge in a nitrogen-methane mixture. Analyses of these tholins have shown that their composition is dependent upon the chemical conditions under which they formed. Hydrolysis of tholins can produce significant quantities of amino acids [1]. A key question for Titan would be whether hydrolysis has occurred, the type of compounds formed and comparing with work carried out on Earth [3].

A Titan chemistry instrument will have to cope with a wide range of materials and should be comparable with techniques used in terrestrial labs so that direct comparison can be made with synthetically produced samples. The proposed Titan chemical analyser uses the powerful technique of GC x GC MS where the sample is separated into individual compounds and then analysed by a high resolution ($M/\Delta M$ >10 000) mass spectrometer. A repeat analysis can then be used to target individual components which are diverted to a separate mass spectrometer for accurate isotopic analysis. Pyrolysis and/or chemical techniques will be required to prepare the samples for analysis and to process the GC elutant for isotopic analysis, similar to that already used on the Ptolemy instrument [2]. Since chemical techniques are already incorporated it is possible to add an ExoMars biomarker type experiment which can be used to detect specific target molecules [4].

Both Montgolfière and lake landers are suitable platforms for the proposed Titan chemical analysers. A Montgolfière allows a range of atmospheric locations to be analysed over a long duration and would concentrate on the aerosol particles. Isotope analysis would help determine the origin of the initial components. Surface material will consist of loose particles that can be readily grabbed. A lake lander can detect any further chemistry occurring in a liquid environment. Of particular interest would be any sediment occurring at the liquid/solid interface.

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